

# Grow Beasts

growing mathematical understanding

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## Introduction

What do you do when you want to get your Stage 3 students authentically and enthusiastically engaged in the active construction of their understanding and fluency with measurement, data collection, representation and interpretation? How do you enable them to make choices about their learning, to measure with purpose, to record and organise the data they produce, to plot the points and to understand that the emerging line tells a story about something real, something changing. Here's one way to approach all of these objectives in an integrative and motivational context. Call in the Grow Beast!

The Grow Beast is a small, inexpensive, readily available toy that, when placed in water, absorbs it and thus 'grows' over the course of several days, then gradually shrinks to more or less its original size when removed from the water. Some Grow Beasts are dinosaurs but others are insects, sea creatures, lizards, zombies and just about everything else that can be molded from this special substance, a super-absorbent hydrophilic (water-loving) polymer. This is like the stuff you will find if you slice open a disposable nappy. Its key feature is that it absorbs liquid. In a nappy it is formulated so as to do this very quickly. In a Grow Beast the process takes days. Further, and this is one of the things that makes them such versatile subjects for investigation, Grow Beasts absorb different liquids at very different rates. Water will work but so will ginger beer, milk, tomato sauce, and nearly any other liquid students care to try. But in each of these liquids they grow and subsequently shrink at different rates. Therein lies one of the keys to success in this activity.



Figure 1: Grow Beasts

## Our aims for this unit

In this unit we aim for the development of skill and understanding in three related content areas. First we want students to construct, through iterative experience, their understanding of the overarching idea that mathematics may be used to analyse, represent, and predict change. As part of this larger process students become engaged in the data representation and interpretation (ACMSP169), a central aspect of their work in statistics and probability in Year 7 (ACARA, 2014). Second, and as a means to enable the first goal, we want students to develop their fluency with measurement. This standard is addressed in Stage 3 as part of the Measurement and Geometry strand (NSW BOS, 2012), but further development gives students a better grip on this common and versatile problem-solving tool. Finally, students will learn about the use of graphs as a means of representation, analysis and communication in mathematics. Because Grow Beasts expand quickly at first and then more slowly over time, the measurement of such variables as length and mass yields non-linear data when plotted against time. This is typically taken up in Stage 5. Nevertheless, students are so closely involved in the production and collection of the data that they seem to have very little trouble understanding the meaning of the curve that is produced from a plot of, for example, length versus time. The investigation serves to foreshadow the development of skills that will be the focus of more formal inquiry in Stage 5.

Underlying the entire investigation is an overt emphasis on the development of a productive disposition toward mathematics (Kilpatrick, Swafford & Findell, 2001, p. 131). One of the formally stated aims of the *Australian Curriculum: Mathematics* is for students to become “confident, creative users and communicators of mathematics, able to investigate, represent and interpret situations in their personal and work lives and as active citizens.” (NSW BOS, 2012). Similarly, our intent in this unit is that students will develop productive values and attitudes, including “interest, enjoyment and confidence in the pursuit and application of mathematical knowledge, skills and understanding to solve everyday problems.” (NSW BOS, 2012) Therefore we strive to put students in situations where mathematics enables them to understand more fully a phenomenon that is personally important and engaging. Further, we want that engagement to be as complete as possible, encompassing affective, behavioural and cognitive engagement (Fredricks, Blumenfeld & Paris, 2004; Parsons, Nuland, & Parsons, 2014). We want students to be genuinely and creatively interested in mathematics and to develop a sense that, with diligence and effort, they can learn useful mathematical skills that enable them to make sense of situations that matter to them. The critical and creative thinking skill identified as “inquiring—identifying, exploring and organising information and ideas,” (ACARA, 2014) is also well represented in this investigation.

## Overview of the investigation

This six-day unit of instruction took place in two all-girls classes of Year 6 students. Students were introduced on Monday to the Grow Beasts and to the central question: “How big will they get by Friday?” They were placed in small groups and each group was given a Grow Beast. They got to know their beasts by naming them, drawing them, imagining their back-stories and generally developing an emotional attachment and commitment to the context of the investigation. As the unit got underway, this commitment served to sharpen and sustain students’ focus on the mathematical concepts and skills.

They measured, recorded data, used proportional reasoning to make predictions and discussed the relative merits of different methods with which to make these predictions. Midway through the unit students were each given their own Grow Beast which they grew in a liquid of their own choosing. This gave them additional opportunities for measurement, data analysis and representation as they compared and discussed different growth rates. As the unit drew to a close the teacher engaged the students in supplementary activities designed to help students generalise and extend the understanding and skills they were developing in this unique context.

## The instructional activities

### Day 1

In this 90-minute block the class activities were divided into three main sections: getting to know the Grow Beasts, making a human graph, and determining how to accurately measure and record the Grow Beast's growth. Class began with a short introduction to Grow Beasts, what they are and how they work, and to the central question: "How big will they get by Friday?" Students were assigned to groups of four and each team was given a Grow Beast. Their team tasks were to name their beast, determine its favorite food and activity, make up a brief story about it and predict how big their Grow Beast would grow by Friday (Day 5). The Grow Beasts all began with lengths of approximately 4 cm. The final lengths predicted by the teams ranged from 9 cm -15 cm and were based on little more than what a few of the students knew from prior experience with similar toys. These naïve and only loosely mathematical guesses served as a useful backdrop for the much more explicitly mathematical predictions that were enabled as the data accumulated over the course of the unit. Teams recorded their responses, including colourful back stories and illustrations in booklets created specifically for this investigation.

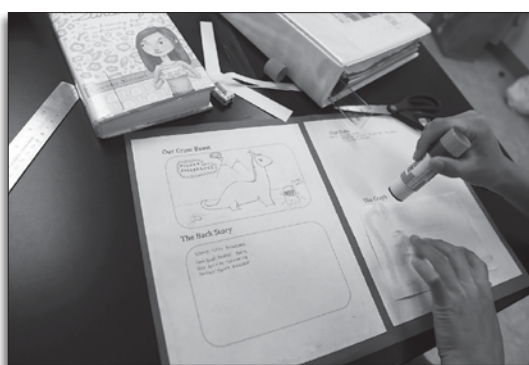


Figure 2. A group's Grow Beast booklet.

The opening activity was followed by a brief discussion of students' prior knowledge of graphs, the x- and y-axes, and how a graph tells a story about the data. We discussed as a class how to best keep track of the Grow Beast's growth using a graph and generated some ideas about how the graph would enable data-driven predictions. In order to get students both cognitively and kinesthetically engaged in the development of their understanding of how a simple scatter plot works, we adapted a lesson from College Preparatory Mathematics, *Graphing in the First Quadrant* (Dieteker & Baldinger, 2011)

in which students create a 'human graph.' On the classroom floor we used masking tape to represent the x- and y-axes. Students were split into groups and engaged in a number of simple activities meant to help them develop and solidify their understanding of graphing in the first quadrant of the Cartesian plane.

In the last activity of the day students reviewed their understanding of measurement with centimetres and millimetres. Attention then returned to the earlier discussion of how to set up a graph for recording growth over time. Presented with a few different options for organising the graph, students quickly agreed that the days of the week should be on the x-axis, and the length should be in centimetres on the y-axis. The terms, dependent and independent variable were reviewed. Each group was given a graph already set up with time as the independent variable on the x-axis and length as the dependent variable on the y-axis. Then they measured their group's Grow Beast to the nearest millimetre and plotted that point on their graph. The most exciting moment of the day came when students placed their beast in a bucket of water and the growing began.

## Day 2

The excitement that bubbled in the room on day two was palpable as students crowded around the buckets to see how much the beasts had grown overnight. With rulers in hand, students were directed to measure their Grow Beast and record the time and length in a table in their booklet. Students were asked to determine how much time had passed from the end of the previous day's class to the beginning of today's class without using pencil or paper. This provided an opportunity to exercise mental mathematics skills and to share different strategies for determining elapsed time. With the measurement and elapsed time in hand they were ready to plot the second point on their graph. Next, using the data they had just collected, students made and shared predictions about how much their Grow Beast would increase by tomorrow's class. Then, within their group they were asked to predict how much they thought their Grow Beast would increase by Thursday and then by Friday. Students plotted their predictions on their graphs and were given the chance to share with the class both the predictions and the reasoning they employed in making the prediction.



Figure 3. Group and their Grow Beast.

The next task was to create a class graph upon which each group would record their Grow Beast's growth, allowing the class to easily view and compare the different growth rates. This provided another opportunity to discuss appropriate scale when setting up graphs. Each group placed their data on the class graph using a different coloured marker. The final activity of the day was a short exercise dealing with linear and non-linear graphs and the different sorts

of stories they tell. Finally, students were primed for receiving their individual Grow Beasts. Spirited discussion ensued as to how different liquids might influence the growth of the beasts. Students were reminded that if they did not want to use grape juice, lemonade or cola, which the teacher would provide, they should bring in the growing liquid of their choice in a small container.

### Day 3

After new measurements of the group Grow Beasts were made, recorded and plotted on both the class chart and in the group booklets, the class began working on their individual Grow Beast projects. Students were very excited to take ownership of their own Grow Beast's fate and had brought in interesting liquids including so called "energy drinks," window washing liquid, orange juice, and rubbing alcohol. As with the group Grow Beasts, students created their own little booklet to record information about their individual Grow Beasts. They were given time to write a short story and draw a picture of their beast, and many students creatively poured over their booklets, making intricate family histories and personal stories for their small polymer pets. They made a data page and used a ruler to construct a graph, thinking carefully about scale. They left two pages for a conclusion and further questions. Students marked the time, measured their beast, plotted the point and placed their beast in their chosen liquid.

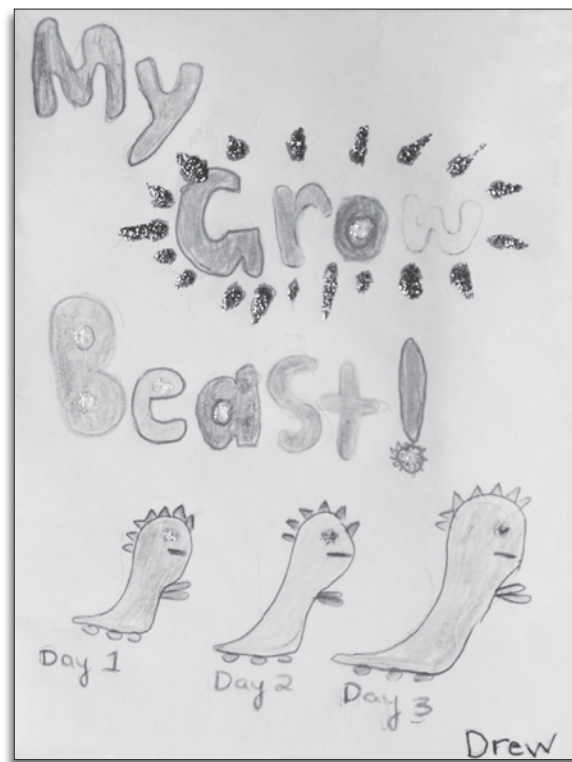


Figure 4. An individual student's booklet.

### Day 4

Class began with students measuring, recording, and plotting the growth of their group Grow Beasts, now in their third day of growth, in the group booklets and on the class chart. Attention then turned to students' individual beasts. The variety of liquids students had chosen for their individual beasts naturally led to conversations comparing the differing growth rates. Having recently completed

a unit on ratios, rates, and proportions, the teachers were excited to see students computing daily growth rates by dividing the difference in length from yesterday to today by the number of hours elapsed (For example,  $1.3\text{cm}/24$  hours). Some students wanted to be more specific and were able to find the growth rate per hour. Once students computed their Grow Beast's growth rate, the class discussed how different liquids affected growth rates. The richness of this discussion was a testament to the power of bringing science into the mathematics classroom; because students cared about the hands-on experiment in which they had developed ownership and purpose, mathematics became a meaningful tool used to support ideas and assertions.

Next, students practiced making and reading graphs by using data from their own lives. They made tables of data for things like age and hair length, time of day and minutes exercised, day of the week and minutes spent on technology. They gave their finished data table to a partner to graph the data and summarise the results. This lesson helped students develop fluency with organising, representing and communicating data and with plotting points. Since the numbers came from their own lives, students again were using data and graphing in order to construct mathematical understanding that was personally relevant.



Figure 5. Girls measuring their Grow Beast.

## Day 5

On the fifth day students measured and recorded their group dinosaurs for the last time. Using the large class graph begun on the second day, students analysed the different growth patterns that had emerged. Some grew rapidly at first and then tapered off, while others grew more steadily over the course of the week. Students also measured and recorded their individual Grow Beasts and made predictions about how much they would grow over the weekend.

The lesson of the day centered on the use of scatter plots to depict the relationship between dependent and independent variables. The intent was to help students extend the understanding they were building beyond the confines of the Grow Beast investigation. The class was divided into three groups, and each explored a different scenario that required graphing in order to make predictions:

1. circumference of a balloon vs. the number of breaths blown into it,
2. (number of handfuls vs. the total number of unifix cubes gathered, and
3. the distance a toy car traveled from the end of the ramp vs. the elevation of the starting point on the ramp.

Each group was asked to carry out their experiment and graph their results. This led to sharing the different types of graphs (linear vs. non-linear) and to a rich discussion regarding mathematical prediction.



Figure 6. The groups engage in discussions about mathematical prediction.

## Follow-up

Over the weekend, students' individual Grow Beasts continued to grow, although some grew slowly or not at all, depending on the liquid. Students were excited to make their final measurements, to find out what had happened with the other Grow Beasts in the room and to record and plot their data in their booklets. They wrote a conclusion about the experiment, which included comparing the different growth rates of both group and individual Grow Beasts. This was an opportunity to engage in some mathematical reasoning, supported by the data they collected. An examination of these conclusions across the classes shows that most students were concerned primarily with a numerical representation of the overall growth of their dinosaur and how that change compared to others. Many computed the rate of growth for their beast and noted the non-linear nature of change over time. One student wrote the following for her conclusion:

I discovered that Marvin grew the most on Wednesday night. He grew 1.5 cm. But after that he only grew about 0.5 cm (per day). Our group Grow Beast grew bigger in water than in lemonade. Their (sic) were two other people that did lemonade and their Grow Beasts only grew to 7 centimetres long. Another person did cola and her Grow Beast grew to 11 centimetres. There must be something in the lemonade that makes it grow slower.

## Conclusion

The evidence provided by their work shows that students were successfully engaged in the development of understanding and skill with respect to the curricular aims identified at the beginning of this article. Students learned something about the use of mathematics to analyse, represent and predict change. They developed their skill with measurement and with the use of data and graphs to represent and communicate about a real-life situation. Further, they were engaged in the work. They enjoyed themselves and developed some degree of confidence in their ability to use mathematics as part of the inquiry process.

In this day and age, with its emphasis on standards and testing, it is easy to lose track of our students' need to experience personal meaning in the mathematics they learn. If we are not careful, we allow our teaching to drift toward the development of mechanical, testable skills without the understanding and personal engagement that enables retention and impels application. This investigation targets an important set of mathematical skills and builds a context that invites students to participate in their own learning. Our goal is always to enable students to develop their own abilities to use mathematics as a way to make better sense of the world – not just the world described in mathematics texts, but the world in which they live, the world that interests them. Further, we want students to see themselves as capable and successful learners of mathematics. Students who are successful with this unit have taken a step toward that level of mathematical proficiency.

## References

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## Grow Beasts are easily obtained via the Internet

Search for 'Growing Dinosaurs.' The first author also maintains a website focused on the use of Grow Beasts in mathematics and science classrooms (<http://growbeast.wikispaces.com/>). Included on the website are curricular ideas and notices as well as links to commercial sources for the purchase of Grow Beasts.

